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(54) Belt for a continuously variable transmission.

(57) A belt has an endless laminated metal carrier (8) and a plurality of metal elements (7) engaged with the carrier. A residual stress is provided in the carrier such that sum of moments of the residual stress in the carrier becomes zero at a radius of an arc, at which lines indicating an outer surface maximum stress and an inner surface maximum stress of the carrier intersect each other (Figure 6). Namely both the stresses becomes small at the same time at the radius.

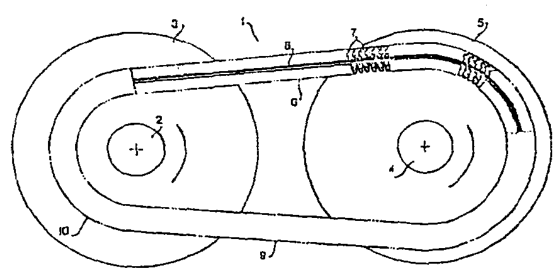


FIG. 1

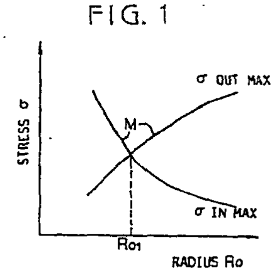


FIG. 6

EP 0 279 645 A1

Description

Belt for a Continuously Variable Transmission

The present invention relates to a belt for a belt drive device, and more particularly to a belt for a continuously variable belt-drive transmission for a motor vehicle.

A known continuously variable belt-drive transmission comprises an endless belt running over a drive pulley and a driven pulley. Each pulley comprises a movable conical disc which is axially moved by a fluid operated servo device so as to vary the running diameter of the belt on the pulleys in dependence on driving conditions.

The belt comprises a pair of endless carriers and a plurality of metal elements arranged in series on the endless carriers, the carriers engaging in opposed slits of each element. Each carrier comprises a plurality of laminated metal strips.

The carriers are repeatedly bent and straightened as they pass around the pulleys and the straight running sides, so that stresses are produced in the carriers. If the stress exceeds a fatigue limit, the belt may break down by repeated stress. Thus, the service life of the belt becomes short. Japanese Patent Laid Open No. 53-42172 discloses an endless metal carrier which is preliminarily bent to provide a residual stress (internal stress) in the carrier so that a maximum stress which is produced in the carrier during the operation may be below the fatigue limit. Accordingly, strength against repeated bending and straightening is improved.

However, the residual stress given in the carriers is not always constant. Accordingly, dependent on the residual stress, the maximum stress may exceed the fatigue limit. Thus, the strength of the belt can not be sufficiently improved.

The present invention seeks to provide an endless metal carrier for a belt of a continuously variable belt drive transmission where in a maximum stress may be reduced, thereby extending the service life of the belt.

According to the present invention, there is provided a belt for a continuously variable transmission, comprising an endless metal carrier and a plurality of metal elements engaged with the carrier, characterised in that a residual stress is provided in the carrier such that the sum of moments of the residual stress in the carrier becomes zero at a posture where an outer surface maximum stress and an inner surface maximum stress of the carrier are equal.

In an aspect of the invention, the carrier comprises a laminated plates, and the posture has arcuate form.

A preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is an elevational view of a belt device;

Fig. 2 is a schematic cross section of the belt device of Fig. 1;

Fig. 3 is an elevational view of an element and carriers of a belt;

Fig. 4 is a diagram showing endless metal carriers in which residual stresses having different values are provided;

Fig. 5 is an enlarged view of a part of a belt and pulley device; and

Fig. 6 is a graph showing a relationship between maximum stresses and radius of the arc of the carrier.

Referring to Figures 1 to 3, a belt-device 1 in which a belt of the present embodiment is shown, has an input shaft 2 and an output shaft 4 provided in parallel with the input shaft 2. A drive pulley 3 and a driven pulley 5 are mounted on shafts 2 and 4 respectively. A fixed conical disc 3a of the drive pulley 3 is integral with input shaft 2 and an axially movable conical disc 3b is axially slidably mounted on the input shaft 2. A conical face of the fixed conical disc 3a confronts a conical face of the movable conical disc 3b thereby forming a groove there-between.

A fixed conical disc 5a of the driven pulley 5 is formed on the output shaft 4 opposite a movable conical disc 5b. Conical faces of the respective discs 5a and 5b form a groove. A belt 6 engages the drive pulley 3 and the driven pulley 5.

The belt 6 comprises a pair of endless metal carriers 8 and a plurality of V-shaped metal elements 7 adjacently arranged along the carriers. Each element 7 has a horizontal slits 7b at each side wherein the metal carriers 8 are inserted.

The carrier 8 comprises laminated layers of flexible thin metal strips 8a, 8b, 8c...... Both sides of lower portion of each element 7 are inclined to form inclinations 7a so as to frictionally engage with the conical faces of discs 3a, 3b, 5a and 5b as shown in Fig. 3.

The engine power is transmitted from the input shaft 2 to the output shaft 4 through the drive pulley 3, belt 6 and driven pulley 5. As the movable conical discs 3b and 5b are axially moved along the shafts 2 and 4, the transmission ratio is continuously changed.

The belt 6 is repeatedly bent as it passes arcuated portions 10 along the pulleys and straightened at straight running sides 9 between the pulleys. The carriers 8 of the present embodiment are preliminarily bent to have a predetermined residual stress so as to be able to cope with such bending and straightening.

Fig. 4 shows carriers 8 each of which is cut at a portion. Each carrier forms an arc having a certain curvature where the sum of the moments of the residual stresses becomes zero. A radius R_O of the arc varies as shown by chained lines 8′ and 8″ in dependence on the residual stress in the carrier 8.

A maximum stress σ inmax produced in inner surface of the carrier and a maximum stress σ outmax produced in the outer surface of the carrier can be represented as follows:

$\sigma\ inmax = E \times h/(2R_O - h)$ ......(1)

$\sigma\ outmax = E \times h \times (R_O - R_M)/2R_O \times$

R_M ......(2)

wherein R_M is a minimum pitch radius of the carrier 8 running over the pulleys as shown in Fig. 5, h is a thickness of the carrier 8 and E is a Young's modulus.

Since the thickness h and the minimum pitch radius R_M are constant in a specific class of a belt drive transmission, the maximum stresses σ inmax and σ outmax change dependent on the radius R_O which is dependent on the residual stress. Fig. 6 shows a relationship between the radius R_O and maximum stresses σ inmax and σ outmax obtained by the equations (1) and (2), respectively. A bold line M in the graph indicates maximum stress produced in the carrier 8 as a whole.

As shown in the graph, when the radius R_O is small, the maximum stress σ inmax of the inner surface of the carrier 8 increases at the straight running sides 9 in the course of the belt 6. When the radius R_O is large, the maximum stress of the outer surface of the carrier 8 increases at the arcuate portions 10. During the running of the belt, when the maximum stress acting on the carrier 8 increases, the strength of the carrier against the repeated bending stress decreases. Thus, in the described instances, the carrier 8 cracks either from the inner surface or from the outer surface as a result of fatigue.

On the other hand, the maximum stress in the carrier 8 as a whole becomes minimum when the outer surface maximum stress σ outmax and inner surface maximum stress σ inmax are equal with each other at a radius R_O1. In accordance with the present embodiment such a residual stress is provided in the carrier that the sum of moments of the residual stress in the carrier becomes zero at the radius (R_O1) where the lines indicating maximum stresses of the outer and inner surfaces intersect each other. Thus, the maximum stresses σ outmax and σ inmax can be reduced to a minimum value.

The residual stress can be provided in the carrier 8 by well known methods. For example, the endless metal carrier 8 is engaged with two tension rollers. A bending roller having a relatively small diameter is pressed against the carrier while it runs by the rotation of the tension rollers.

From the foregoing, it will be understood that the present embodiment provides a carrier for a belt wherein the carrier has an appropriate residual stress so that the carrier is not easily ruptured by fatigue either from the outer or inner surface of the carrier. Thus, service life of the belt can be extended.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

Claims

1. A belt for a continuously variable transmission, comprising: an endless metal carrier (8) and a plurality of metal elements (7) engaged with the carrier, characterised in that a residual stress is provided in the carrier such that the sum of moments of the residual stress in the carrier becomes zero at a posture where an outer surface maximum stress and an inner surface maximum stress of the carrier are equal.

2. A belt for a continuously variable transmission having an endless metal carrier and a plurality of metal element engaged with the carrier, characterised in that such a residual stress is provided in the carrier that sum of moments of the residual stress in the carrier becomes zero at a posture where lines indicating an outer surface maximum stress and an inner surface maximum stress of the carrier intersect each other.

3. The belt as claimed in claim 1 or 2, wherein the carrier (8) comprises laminated plates.

4. A belt as claimed in claim 1 or 2, wherein the posture has an arcuate form.

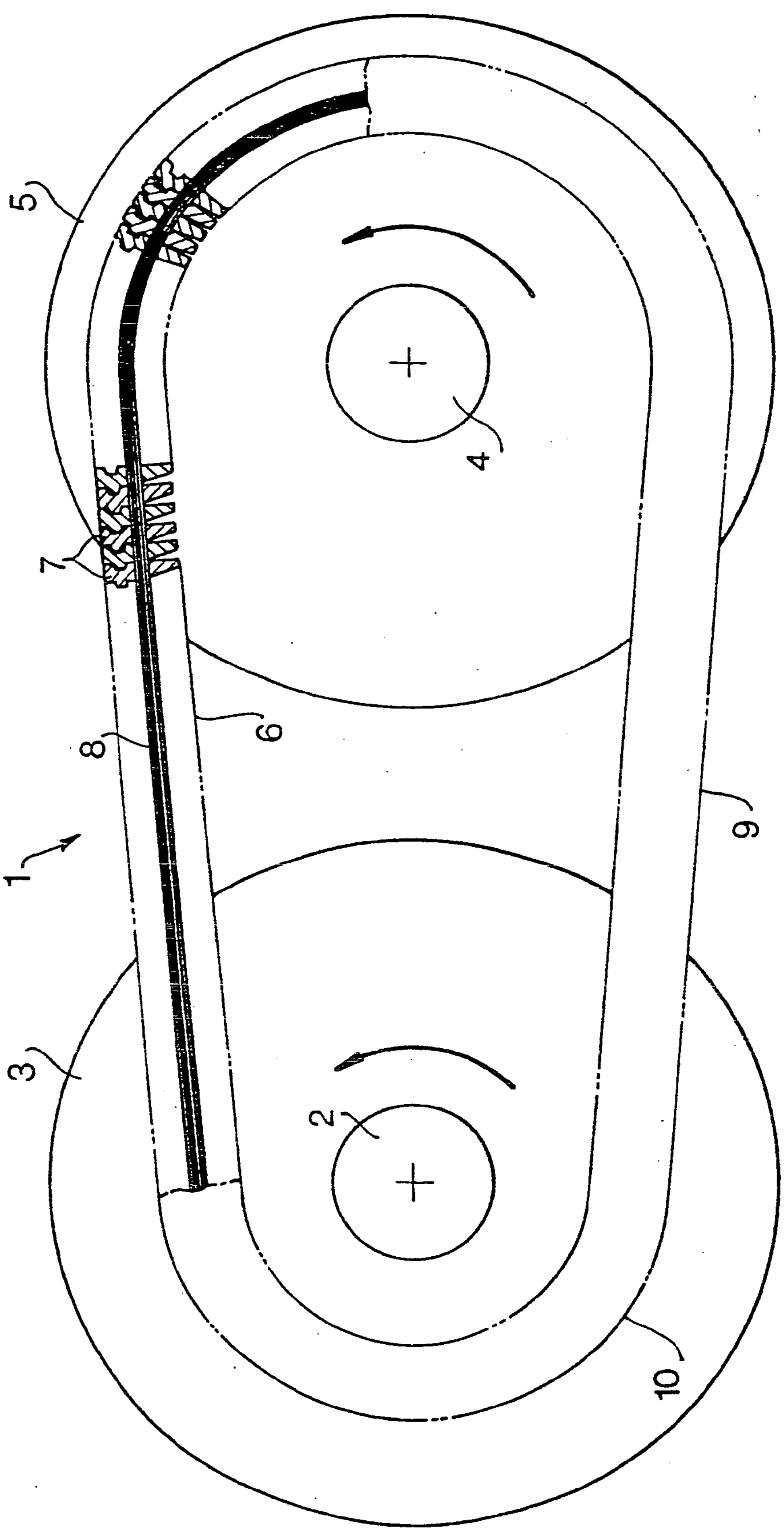


FIG. 1

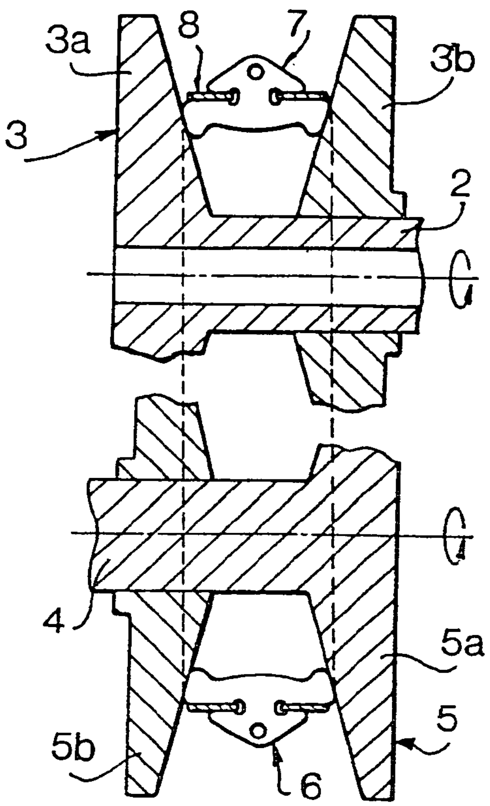


FIG. 2

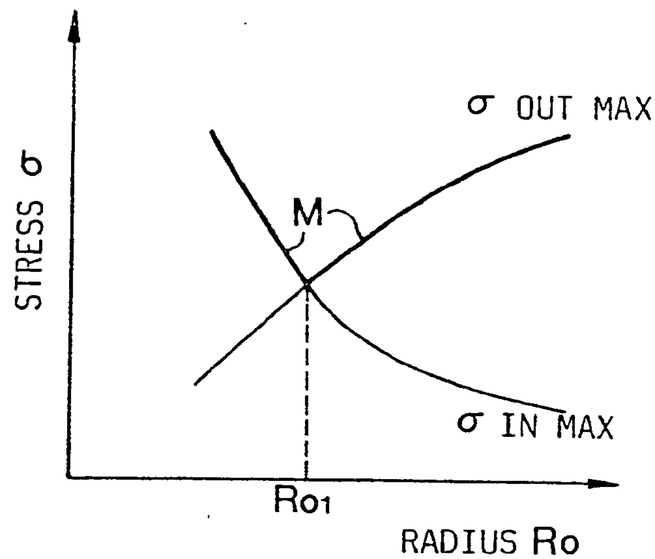
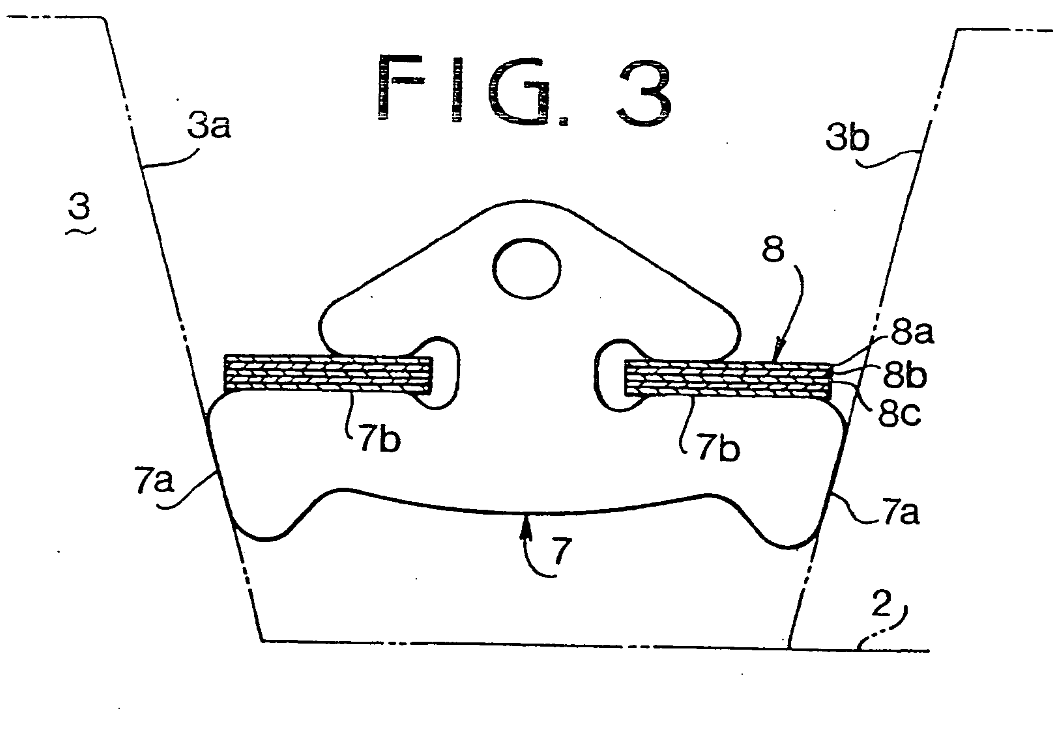


FIG. 6

FIG. 3



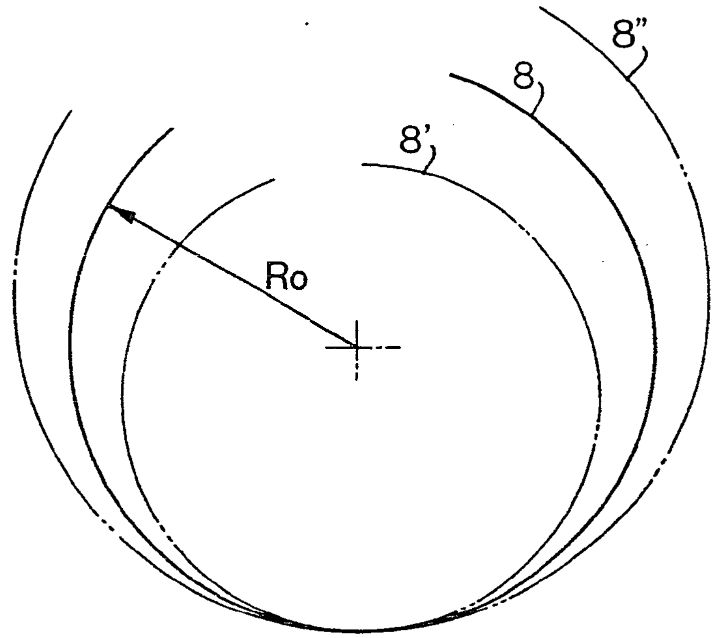


FIG. 4

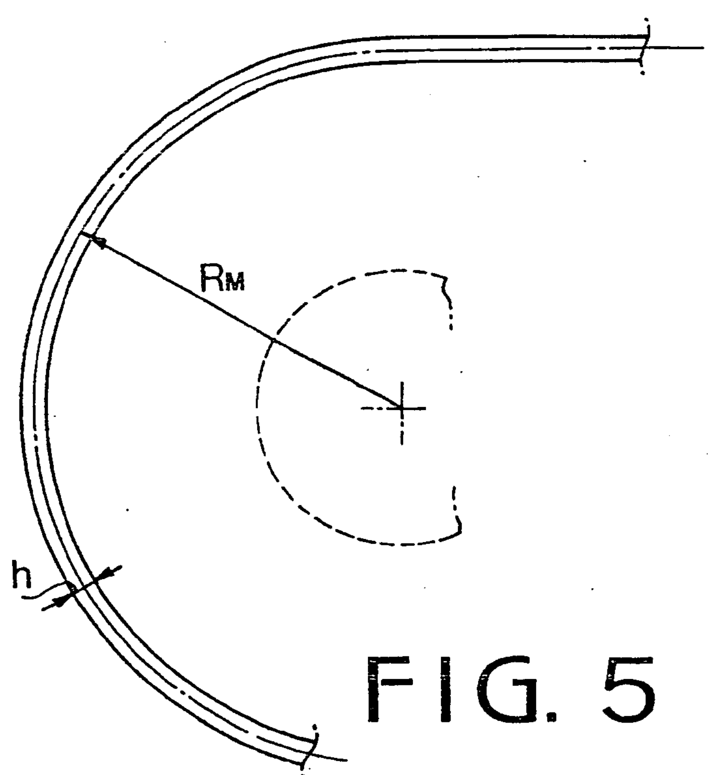


FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 1315

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	GB-A-1 551 474 (VANDOORNE) & JP-A-53 42 172 (Cat. D) ---		F 16 G 5/16
A	EP-A-0 181 670 (GAYLIENE INVESTMENTS) ---		
A	US-A-2 920 494 (DODWELL) ---		
A	US-A-4 579 549 (OKAWA) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)
F 16 G B 61 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30-04-1988	BARON C.

CATEGORY OF CITED DOCUMENTS

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